# Simultaneity of Two Types of Geometrical Illusions

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# SIMULTANEITY OF TWO TYPES OF GEOMETRICAL ILLUSIONS

By
YOSHIAKI NIHEI (仁平義明)

*(Department of Educational Psychology, Niigata University, Niigata)*

Simultaneity of the two types of geometrical illusions, the illusion of length and of orientation, in the Zöllner-type figure was experimentally confirmed. By varying systematically the intersecting angle, the number of intersections, and the length or the height of inducing lines, the magnitude of illusion of length was measured. The effect of the intersecting angle was significant, and the most effective angle in producing the illusion of length was 60°, where the illusion of orientation also occurred. The simultaneity of the two illusions suggested that a common process may underlie the two.

The geometrical optical illusions have been classified into some classes. The classifications are well summarized by Over (1968) and Robinson (1972). According to most classifications, the Zöllner illusion and the Oppel illusion are defined as different types; the former as the illusion of direction (orientation), and the latter as the illusion of distance (length). However, a fundamental difference in the characteristics of the figure between the two lies in the intersecting angle of lines. In the case of the Oppel figure the intersecting angle is 90°, while it is an acute one in the Zöllner figure (Fig. 1). When the intersecting angle is changed from 90° to an acute angle, is apparent distortion restricted to an aspect of orientation? Is it not possible that illusion occurs also in the aspect of length? The primary purpose of the present experiment is to find out whether the illusion of length and the illusion of orientation occur simultaneously in a stimulus configuration of the Zöllner illusion.

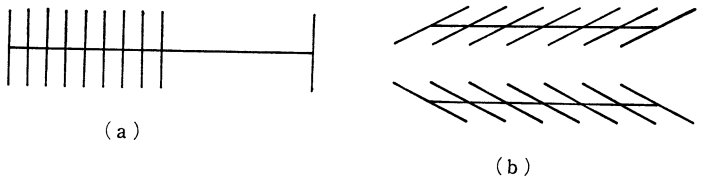


Fig. 1. Examples of geometrical illusions. (a): The Oppel illusion, (b): the Zöllner illusion.

## METHOD

*Stimuli and Apparatus*: The standard and the comparison stimuli were drawn on white Kent paper of 27 cm×38.5 cm with black ink individually. All the lines were 0.5 mm in width. The standard stimulus was composed of a horizontal straight line of

100 mm (5° in visual angle) and of inducing lines attached to intersect it (Fig. 2). The number of inducing lines was a variable in the standard stimulus. Two inducing lines were attached to both ends of the horizontal line, and the intersections were of equal distance. The numbers of sections were 1, 2, 3, 5, and 10. The intersecting angle of lines ($\theta$) also was a variable. There were three $\theta$s: 30°, 60°, and 90°. Other variables were the length ($l$) and the height ($h$) of the inducing lines. Variation of $\theta$, keeping $l$ constant, is accompanied by variation in $h$ necessarily. Similarly, variation in $\theta$, keeping $h$ constant, is accompanied by variation in $l$. Thus, variation in $\theta$ was made under two conditions, the constant height (CH) and the constant length (CL) condition. Both the length and the height in constant were 30 mm (1.5° in visual angle). These variations resulted in twenty-five standard stimuli, and a horizontal line of 100 mm without inducing lines was added to the standard stimuli as a control condition. The comparison stimuli were a set of horizontal lines, varying in length from 70 mm to 130 mm in 2 mm steps. The standard and the comparison stimulus were arranged side by side using a wooden holder on a table (Fig. 3). The subject sat in a chair fixing the head with a chin-rest, and observed the stimuli, which were on the same level with his eyes, at a distance of 115 cm.

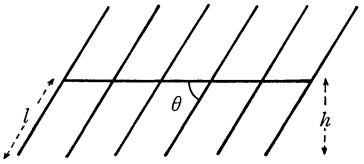


Fig. 2. An example of the standard stimulus and illustration of variables. $\theta$=intersecting angle, $l$=length, and $h$=height.

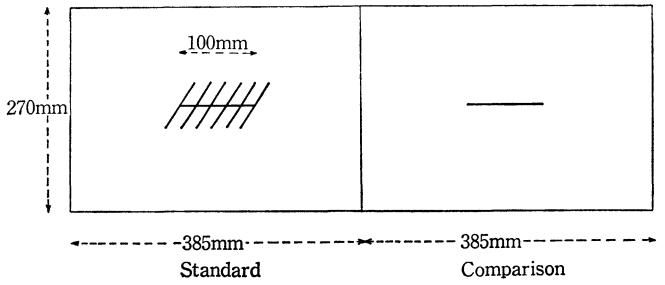


Fig. 3. The arrangement of stimuli.

*Procedure*: The method of limits was used. The subject was asked to judge whether the horizontal line of a standard stimulus is longer (or shorter) than a comparison stimulus. There were four sequences of trials for each standard stimulus, two ascending and two descending. All the variables described above were within-subject variables. The order of presenting the standard stimulus was randomized within a subject, and the left-right arrangement of the standard and the comparison stimulus was counter-

Table 1. The magnitude of illusion for all stimuli.

| N. of sections \ θ | 90° | 60° | | 30° | |
|---|---|---|---|---|---|
| | | CL | CH | CL | CH |
| | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) |
| S 1 | 3.6mm(2.5)* | 6.5mm(2.8)** | 6.6mm(1.7)** | 4.8mm(3.3)** | 1.1mm(2.4) |
| S 2 | 4.0mm(1.8)** | 5.2mm(2.7)** | 5.2mm(2.8)** | 2.9mm(3.1) | 1.8mm(3.2) |
| S 3 | 4.4mm(2.9)* | 6.3mm(3.2)** | 6.8mm(3.2)** | 3.5mm(3.8)* | 2.4mm(3.5) |
| S 5 | 6.0mm(2.9)** | 8.0mm(3.3)** | 8.2mm(3.6)** | 4.8mm(4.2)* | 4.4mm(4.5) |
| S10 | 6.5mm(3.7)** | 8.4mm(3.8)** | 8.9mm(2.9)** | 4.6mm(4.3) | 4.6mm(4.8) |
| Control | −0.3mm(0.7) | | | | |

* Significance of illusion, $p<.05$. ** $p<.01$.

balanced over trials.

*Subjects*: Five female and two male undergraduates served as subjects. All had normal vision.

## Results

The magnitude of illusion was defined as the difference between PSE that each subject judged equal to the standard stimulus and the actual length (100 mm). The averages of illusion are given in Table 1 for all conditions. Occurrence of the illusion was statistically confirmed by comparing the magnitude of illusion in each standard stimulus with that of the control stimulus using $t$ tests. Statistically significant illusions occurred under all the conditions when $\theta=90°$ and 60°. While, at $\theta=30°$, significant illusions occurred only under CL conditions.

Fig. 4 and Fig. 5 show the magnitude of illusion as a function of the intersectiong angle ($\theta$) and of the number of sections. Each represents the same data. The effect of $\theta$ was significant, and the most effective $\theta$ in producing illusion was 60°. The effect of the number of sections was also significant. Generally speaking, the more sections there were, the more illusion was produced. However, under some conditions, two sections (S2) caused the lowest magnitude of illusion.

Variations in $l$ and $h$ were almost ineffective. A significant difference of illusion between CL and CH condition was found only when $\theta=30°$ and S1 ($t_0=4.61$, $df=6$, $p<.01$).

## Discussion and Conclusion

The most effective intersecting angle in producing the illusion of length was not 90° but 60°. Finer variation in the angle might be necessary to determine the exact $\theta$ which causes the highest magnitude of illusion. However, the most significant point of the present results is the fact that the illusion of length occurs in a Zöllner-type figure, where the illusion of orientation occurs. Although the illusion of orientation was not directly measured in the present experiment, most subjects spontaneously reported the

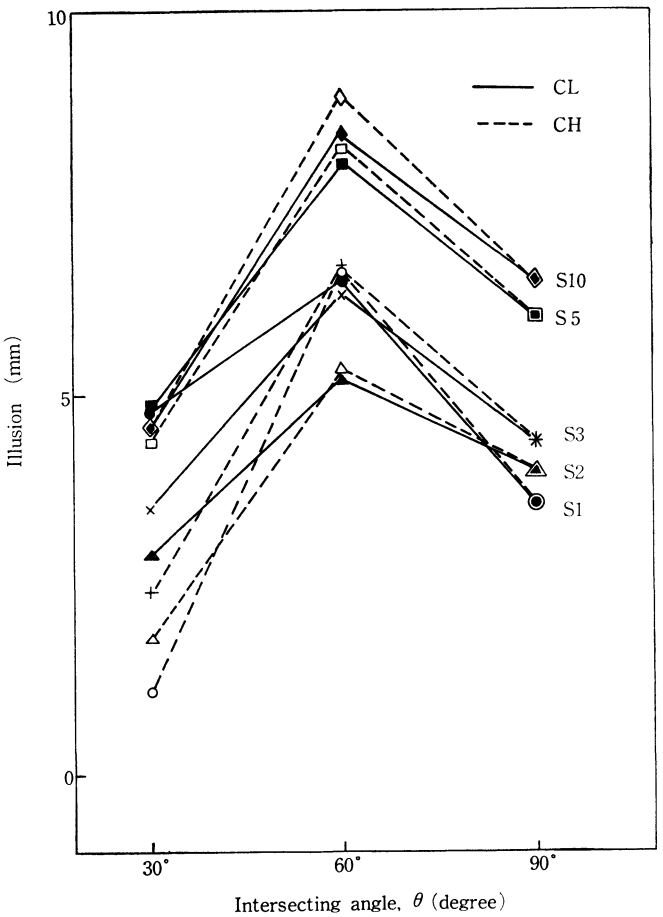


Fig. 4. The magnitude of the illusion of length as a function of the intersecting angle ($\theta$). Solid lines represent illusions under the constant length condition (CL) and broken lines represent illusions under the constant height condition (CH). S1–S10 are the number of sections.

apparent distortion of orientation of the horizontal line, which was similar to the Zöllner illusion.

This simultaneity of the two types of geometrical illusions, the illusion of length and of orientaion, suggests that it may be insufficient to describe the Zöllner illusion only as the illusion of orientaion, and that a common process may underlie the two types of illusions that had been dealt with separately.

The variation in the height or the length of inducing lines was almost ineffective. Oyama (1975) found, systematically examining the determinants of the Zöllner illusion, that the illusions reach asymptotes about the height of 45 min to 1 degree (in visual angle). The present result may be explained on the basis of Oyama's data, for the inducing lines were long enough for the illusion to reach an asymptote in the present

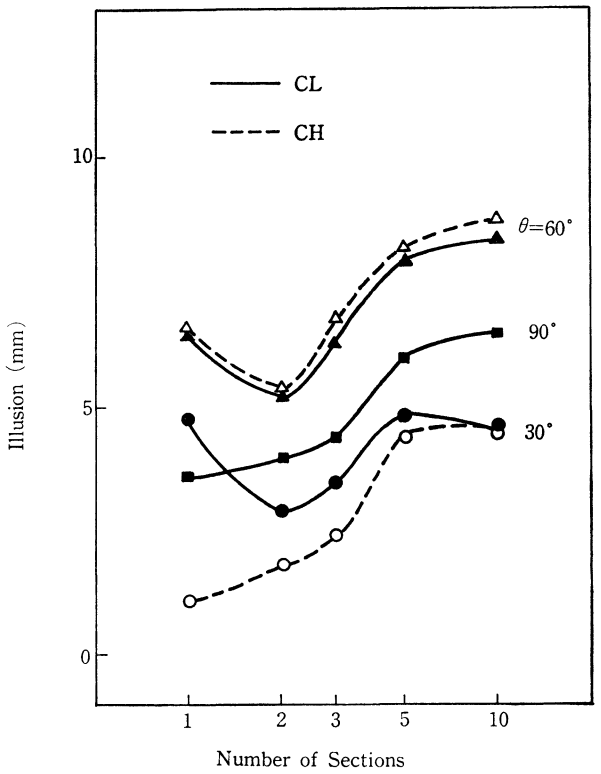


Fig. 5. The magnitude of the illusion of length as a function of the number of sections. The same data as Fig. 4.

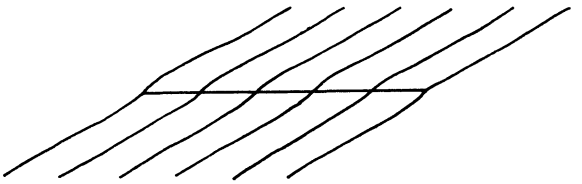

Fig. 6. An exaggerated drawing of the reported distortion of inducing lines.

experiment.

Finally, it must be noted that *S*s often reported apparent distortion of inducing lines. An exaggerated drawing of the distortion is shown in Fig. 6. Thus, apparent distortions occur not only in the illusory line (the horizontal line) as the illusion of lenght and of orientation, but also in the inducing lines.

## References

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